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14. ABSTRACT
Cockpit moving-map systems have provided heightened situation awareness to the fighter pilot for more than ten years, but these systems have yet to be integrated into military helicopters. The Navy now plans to install a moving-map system into its new, multi-functional MH-60S helicopter, which will perform mine countermeasures (MCM), combat search and rescue, special operations, and logistics. Other H-60 variants (e.g., SH-60B) perform anti-submarine warfare (ASW), surface warfare, surface surveillance, and other missions.

Naval Research Laboratory scientists were tasked to demonstrate and evaluate the potential of a cockpit moving-map for enhanced situation awareness during multi-functional helicopter missions (particularly MCM and ASW). This project consisted of three main tasks: 1) conduct a web-based survey of pilots and aircrew experienced in MCM and ASW for their preferences with respect to various environmental data that could be displayed in a moving-map; 2) demonstrate and evaluate pilot-preferred data on existing moving-map displays; and 3) recommend potential data types to be collected and displayed in a multi-mission helicopter.

15. SUBJECT TERMS
moving-map systems, mine countermeasures, flight path, tow fish location, tow fish depth, sediment bottom type (e.g., sand, mud, rock), threat rings, and historical data (e.g., known non-mine objects)

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AN ON-LINE EVALUATION OF COCKPIT MOVING-MAP DISPLAYS TO ENHANCE SITUATION AWARENESS IN ANTI-SUBMARINE WARFARE AND MINE COUNTERMEASURES OPERATIONS

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ABSTRACT. Cockpit moving-map systems have provided heightened situation awareness to the fighter pilot for more than ten years, but these systems have yet to be integrated into military helicopters. The Navy now plans to install a moving-map system into its new, multi-functional MH-60S helicopter, which will perform mine countermeasures (MCM), combat search and rescue, special operations, and logistics. Other H-60 variants (e.g., SH-60B) perform anti-submarine warfare (ASW), surface warfare, surface surveillance, and other missions.

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This poster presents preliminary results from our survey of helicopter aircrew, as well as sample map displays. A total of 60 pilots, airborne tactical officers and sensor operators responded to the on-line survey. The participants represented five different helicopter platforms: HH-60H (6 pilots), MH-53E (2), MH-60S (1), SH-60B (45), and SH-60F (5). One P-3 (fixed-wing) pilot also responded. Four map types were evaluated: scanned aeronautical charts, nautical charts, gridded bathymetry, and acoustic imagery of the seafloor. Six potential overlays also were evaluated: flight path, tow fish location, tow fish depth, sediment bottom type (e.g., sand, mud, rock), threat rings, and historical data (e.g., known non-mine objects). The Office of Naval Research sponsored this project as part of the Naval Research Laboratory's Generation and Exploitation of the Common Environment (GECE) Program.

1. INTRODUCTION

The objective of this project was to evaluate potential benefits of a cockpit moving-map to ASW and MCM operations in the Navy's new multi-function MH-60S helicopter. The evaluation was aimed at H-60 pilots, since the Navy plans to implement the first helicopter moving-map system in the MH-60S for land-based combat search and rescue (CSAR) operations. The MH-60S also will perform ASW and MCM missions, but no one had determined how a moving-map could best support these sea-based operations. Since the MH-60S is in the test phase of development, there are few experienced MH-60S pilots to survey. Instead, we targeted pilots of existing platforms (including other H-60 variants, plus the P-3 and MH-53), engaged in ASW and MCM missions, to gain a broader understanding of how a moving-map system might benefit these missions in the new MH-60S.

Naval fixed-wing aircraft display three geospatial data types in their moving-maps: scanned aeronautical charts, satellite imagery, and terrain elevation data. While these products are excellent SA tools for land-based flight, they provide limited information for shallow-water operations, such as ASW and MCM. We wanted to demonstrate that ASW and MCM SA needs could be addressed by a cockpit moving-map that displayed equivalent sea-based geospatial products – such as scanned nautical charts, acoustic imagery, and bathymetry – in place of the land-based data. Similarly, certain overlays that are generated for land-based missions (e.g., height-above-terrain and clear line-of-sight) could be adapted for sea-based missions by substituting bathymetry for elevation data in the terrain masking algorithms, potentially improving SA for the pilot and/or sensor operator of an ASW or MCM mission.

2. APPROACH

NRL conducted a web-based survey of ASW and MCM aircrew for their preferences with respect to sea-based geospatial data that could be displayed in a moving-map. This survey followed the general format of a 1995 survey conducted for the Naval Air Systems Command (Lohrenz, et. al, 1997). Pilots and aircrew were presented with sample maps and questioned concerning their map requirements and preferences. Like other surveys of its genre (e.g., Aleva, 1999), the previous study required dedicated interviewers and only reached a limited number of participants who were stationed at a specific location during the interviewing period. In contrast, the web approach surveyed more participants with minimal impact to normal duties, and no dedicated interviewers were required.

The on-line survey consisted of 10 web pages (table 1) and took approximately 45 minutes to complete. Participants were instructed to complete one page before continuing to the next. After completing each page, they

could either continue or exit from the website and return later without having to repeat any pages. The registration page included information such as military service, primary aircraft, flight experience, mission experience, and experience with existing cockpit moving-maps. This information was used to categorize the results and to consider whether a particular type of map display would be more useful for one type of aircraft or mission, or whether a pilot's responses might be related to his or her flight experience or familiarity with digital moving-maps.

The survey provided pictures and descriptions of each display, followed by several questions. The survey was designed to be as quantitative as possible to facilitate data analysis, although ample space was provided for comments. Survey I instructed participants to evaluate four map types (fig. 1), as follows:

Table 1. Outline of Pilot Preference Survey

	Registration and Aircrew Profile (p. 1)
I.	Survey of four map types (pp. 2-3) – shown in figure 1
II.	Survey of six potential overlays (pp. 4-9) – figure 2
III.	Survey of six potential future displays (p. 10) – not included

(a) Rate each map on a scale from 1 (of no use) to 5 (extremely useful);
(b) Specify anticipated uses: general navigation, SA, target location, towed sensor control, hazard avoidance;
(c) Specify required geographic coverage (i.e., land, sea, both or neither);
(d) Specify display mode (moving-map, static picture, both or neither);
(e) Specify required display ranges (from 0.5 to 200 nautical miles).

Survey II asked participants to individually evaluate six mission overlays (fig. 2) using questions (a) and (b), above. Participants then were instructed to combine two or more overlays together and evaluate the result using questions (a) and (b) plus a question to evaluate "clutter" (i.e., data content) on a scale from 1 (not enough information) to 5 (much too cluttered), with 3 indicating "just enough information." The overlays were evaluated first with no underlying map, and then with each of the maps evaluated in Survey I.

Figure 1. Maps evaluated: (a) aeronautical chart; (b) bathymetry; (c) acoustic imagery; (d) nautical chart.

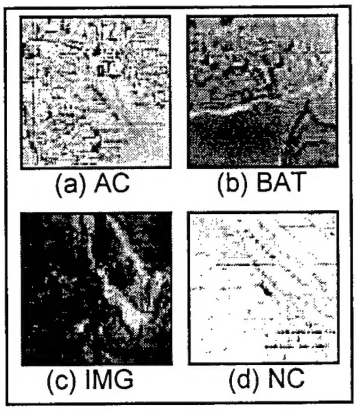
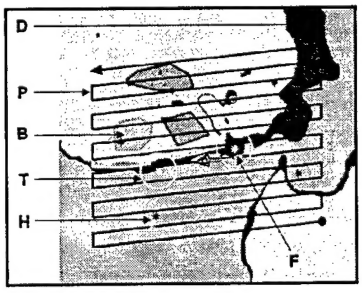


Figure 2. Overlays evaluated: (a) tow Fish; (b) Depth of tow fish; (c) flight Path; (d) seafloor Bottom (e.g., sand, mud, rock); (e) Threats; (f) Historical data.



3. RESULTS

This poster presents preliminary results from the on-line survey. The final project report will be published later this year. Registrants included 49 aircrew from six platforms (fig. 3). 73% of the population consisted of SH-60B pilots. Figure 4 gives flight and mission experience by total flight hours per platform. Our survey population had considerably more experience with ASW missions (22,201 total flight hours) than MCM (3,195), so most of our results pertain to ASW. However, MH-53 pilots surveyed fly MCM missions almost exclusively, so their answers shed light onto the potential contributions of a moving-map to MCM. We combined SH-60F and HH-60H into one group based on missions flown (fig. 4).

As shown in figure 5, the mean rating of each map type was over 3 (*of use*) for all pilots: aeronautical charts were rated highest (4.2), followed by bathymetry (3.9), nautical charts (3.8), and acoustic imagery (3.4). Some significant deviations from these overall means included a low rating (2.5) of bathymetry by the MH-60S pilot, very high ratings (4.7) of imagery by MH-53E and MH-60S, and a very high rating (5.0) of nautical chart by MH-53E.

The most frequently selected overlays (independent of aircraft type), in order of popularity, were bottom type (B), flight path (P), threat rings (T), and historical data (H), as shown in figure 6. The most common overlay combination consisted of these four (PBHT), followed by a combination of the top three (PBT). The clutter ratings for these two combinations were close to the midpoint (3=just enough information), regardless of the underlying map: clutter ratings ranged from 3.7 (PBHT over aeronautical chart) to 3.0 (PBT over bathymetry).

4. CONCLUSIONS

Preliminary survey results indicate that ASW / MCM helicopter pilots are very interested in the potential of cockpit moving-maps to support their operations, and all four map types are worth investigating for these missions. All pilots rated the aeronautical chart display very highly, citing its potential for general navigation and improved SA. Bathymetry and nautical charts also were rated highly by most pilots, citing improved SA and target location.

Many algorithms already developed for terrain data could readily be applied to bathymetry, including elevation (depth) banding, contour line generation, height-above-threshold (or depth-below-threshold) and clear line-of-sight. Although most pilots only rated acoustic imagery "of use" (the average rating), both MH-53E (current MCM pilots) and MH-60S (future MCM pilots) rated it very highly, citing target location, hazard avoidance, and towed fish control, suggesting that a moving-map display of acoustic imagery would be especially beneficial to MCM missions.

Figure 3. Survey Population: 47 pilots / airborne tactical officers and 2 sensor operators (SO).

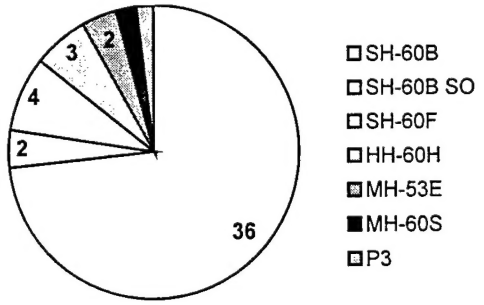
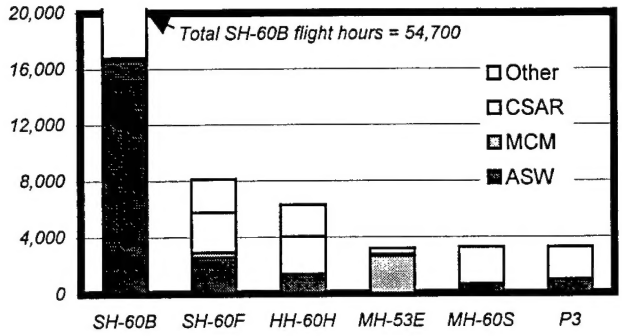


Figure 4. Total flight hours, by mission, for each aircraft platform in survey.



Four of the six overlays were selected far more frequently than the other two: bottom type (B), flight path (P), threat rings (T) and historical data (H). All of these are expected to be of use to both ASW and MCM missions.

Figure 5. Usefulness ratings of evaluated map types, by aircraft type: 1 = of no use ... 5 = extremely useful

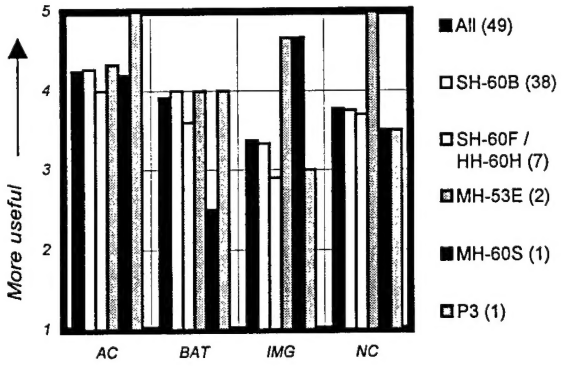
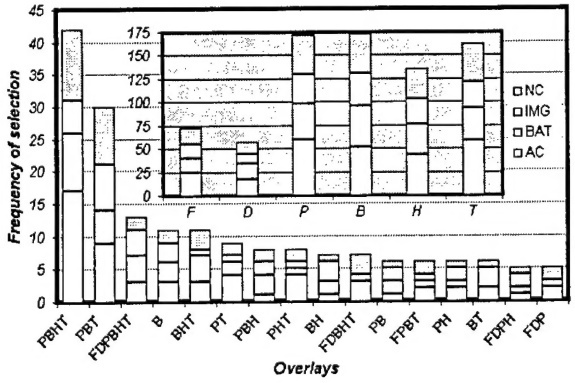


Figure 6. Most frequently selected overlays (inset) and overlay combinations for each map type (all aircraft).



Pilot and aircrew preferences are a good start to any map use evaluation, but the ultimate test is mission performance. Unfortunately, subjects often do not prefer the display that actually produced the best performance (Merwin and Wickens, 1993). We highly recommend that these preference results be used in conjunction with flight performance tests prior to the development and implementation of any new map display system.

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